Environment Canada Environnement Canada

National Hydrology Research Institute

NHRI PAPER NO. 28
IWD TECHNICAL BULLETIN NO. 140

Ground-Water Use in Canada, 1981

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NHRI

NATIONAL HYDROLOGY RESEARCH INSTITUTE
INLAND WATERS DIRECTORATE
OTTAWA, CANADA, 1986

(Disponible en français sur demande)

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Cat. No. En 36-503/140E

ISBN 0-662-14632-8

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Abstract

Estimates of the volume of ground-water use in Canada were prepared for 1981. Six maps show the spatial distribution and annual volumes of ground water used by municipal and industrial users. The major findings of this report are the following: (1) over 6.2 million, or 26% of Canadians, rely on ground water for their domestic supply; (2) approximately 38% of the municipalities in Canada rely entirely or partially on ground water; (3) approximately 1.46 billion cubic metres, or about 4% of total water use in Canada, is obtained from ground water (this percentage is increased to 8% if water use by the thermal component within the industrial sector is not included in the calculations); (4) approximately 87% of total water use for livestock is obtained from ground water; and (5) ground water is important for fish enhancement programs.

Résumé

Le rapport évalue les quantités d'eau souterraine utilisées au Canada en 1981. Six cartes indiquent la distribution géographique et les volumes annuels de l'utilisation d'eau souterraine par les municipalités et les industries. Les principales constatations de ce rapport sont les suivantes : 1) plus de 6.2 millions de Canadiens, ou 26 % de la population, dépendent des eaux souterraines pour leur approvisionnement domestique; 2) environ 38 % des municipalités du Canada dépendent entièrement ou partiellement des eaux souterraines; 3) près de 1.46 milliard de mètres cubes, ou environ 4 % de la totalité de l'eau utilisée au Canada, proviennent des eaux souterraines (ce pourcentage passe à 8 % si l'on ne tient pas compte dans les calculs de l'utilisation d'eau des composantes thermiques dans le secteur industriel); 4) environ 87 % de la totalité de l'eau utilisée pour le bétail est de source souterraine; et 5) les eaux souterraines sont importantes pour les programmes de mise en valeur des poissons.

Glossary

Agricultural user: User who obtains water for livestock and/or irrigation.

Aquifer: An underground formation that contains sufficient saturated permeable material to yield significant volumes of water to wells.

Domestic user: Each person in Canada who relies on water for domestic purposes (total number of domestic users equals the total population).

Ground water: Water obtained from aquifers.

Ground-water user: Water users who obtain their supply from aquifers.

Industrial user: User of water that is self-supplied by a major industrial plant or a fish enhancement facility. An industrial plant is categorized as being a manufacturing, mining or thermal plant. Industrial water obtained from municipal distribution networks is not included in this sector.

Municipality: The definition of municipality varies between the provinces and territories. In the context of this inventory, a municipality is a community of any size which has a municipal distribution network. Whereas a municipality often is an urban centre (population of 1000 or more), municipalities in this report may include communities with populations of 100 or less.

Municipal user: User of water transported and distributed by a municipal distribution network, for domestic, commercial and industrial purposes. Therefore, a municipal user may either be a domestic residence or an industrial, commercial or other type of institution.

Rural user: The balance of the population which is not on a municipal distribution network. Rural users use water for domestic purposes only.

Served (municipal) population: The served population is the population in a municipality that is supplied with water by a municipal distribution network.

Surface water user: Users who obtain their water supply from rivers, streams, lakes and ponds. It may also include water from reservoirs and tides (industrial sector).

Total water use: The combined water use of surface and ground-water users.

Ground-Water Use in Canada, 1981

Paul J. Hess

INTRODUCTION

Growing concern over ground-water resources as a result of supply and contamination problems has emphasized the need for adequate planning and management. An appropriate management strategy would ensure the conservation of a valuable resource and would avoid future costly remedial projects. To date, most Canadian water investigations have been directed toward surface water resources. Consequently, ground-water resources remain poorly understood. The purpose of this report is, therefore, to investigate the magnitude and relative importance of ground-water use compared with total water use in Canada.

The four main objectives of this report are

(1) to estimate the population that relies on ground water
(2) to estimate the volume of annual ground-water use
(3) to indicate the geographic distribution of aquifers and associated ground-water withdrawals
(4) to indicate the relative magnitude of ground-water use to total water use.

The information for this report has been obtained from published and unpublished sources. Sometimes there were gaps in the data. Consequently, both the public and private sectors were consulted to obtain additional information. Because these sectors often relied on approximations and assumptions about general water use, the values in this report are estimates only. The ground-water information was intended to represent 1981; data from other years, however, were substituted when the data for 1981 were incomplete. Detailed explanations on the derivation of some data are given in the appendices.

This report provides national, provincial and territorial values. In addition, information for some of the provinces and the territories has been grouped by region. In this report, the terms "regions" and "regional" refer to the following groupings:

Atlantic Region	Newfoundland, Prince Edward Island, Nova Scotia, New Brunswick
Quebec Region	Quebec
Ontario Region	Ontario
Prairie Region	Manitoba, Saskatchewan, Alberta
British Columbia Region	British Columbia
North of 60 Region	Northwest Territories, the Yukon

Most of the tables provide national, regional, provincial and territorial values, whereas most of the figures emphasize regional values only.

Ground-water users have been classified into four sectors: (1) municipal, (2) rural, (3) agricultural and (4) industrial. A summary section incorporates and combines the ground-water use and user information of these sectors.

Six regional maps indicating the distribution of ground-water use by municipal and industrial users are included (in pocket). Because of the lack of data for ground-water use by the agricultural and rural users it was not possible to indicate their distributions. The section entitled "Regional Maps" identifies the sources used for the plotting of the aquifers and explains the thematic information shown on the maps.

The conclusion summarizes the major findings and offers recommendations on the ground-water data to be collected for resource management.

A glossary has been included for easy access to the definitions of common terms used in this report.

MUNICIPAL USERS

General

Municipal water refers to water transported and distributed by a distribution network for domestic, industrial, commercial and other purposes. Therefore, municipal users are composed of industrial and commercial in addition to domestic users. Approximately 85% of the population served by municipal distribution networks receives water that has been treated prior to distribution (Environment Canada, 1981a).

Population Served by Municipal Distribution Networks

Approximately 80% of the Canadian population was served by municipal distribution networks in 1981 (Table 1). This percentage varied among the provinces, ranging from 27% in Prince Edward Island to 92% in the Yukon Territory. The primary source used to determine these values was the *National Inventory of Municipal Waterworks and Wastewater Systems in Canada, 1981*, henceforth referred to as 1981 MUNDAT (Environment Canada, 1981a). Due to inaccuracies in the 1981 MUNDAT data with respect to provincial total populations served by municipal networks, additional sources were used for some of the provinces.

Data on the population served by municipal distribution networks in the Atlantic Provinces were obtained from "An Assessment of Municipal Water Supply Infrastructure in the Atlantic Provinces" (CBCL Limited, 1984). This publication stated that the 1981 MUNDAT survey overestimated the population served by municipal networks by approximately 90 000 in the Atlantic Region.

For Quebec, Ontario, Saskatchewan and Alberta, 1981 numbers on population served by municipal networks were obtained from D. Lacelle, Environment Canada (personal communication). In his study, preliminary findings indicate that 1981 MUNDAT survey data overestimate served populations by approximately 700 000 in Quebec and 95 000 in Ontario, and they underestimate served populations by approximately 35 000 in Saskatchewan and 50 000 in Alberta.

Table 1. Population Served by Municipal Distribution Networks, 1981

Region, province or territory	Total population 1981*	Population served by municipal distribution networks (municipal domestic users), 1981	Percentage of municipal domestic users to total population
Atlantic Region	2 234 032	1 246 460†	56
Newfoundland	567 681	405 200†	71
Prince Edward Island	122 506	33 260†	27
Nova Scotia	847 442	460 000†	54
New Brunswick	696 403	348 000†	50
Quebec Region	6 438 403	5 645 000‡	88
Ontario Region	8 625 107	7 424 000‡	86
Prairie Region	4 232 278	3 106 882‡§	73
Manitoba	1 026 241	807 282§	79
Saskatchewan	968 313	615 000‡	64
Alberta	2 237 724	1 684 600‡	75
British Columbia Region	2 744 467	1 979 590§	72
North of 60 Region	68 894	58 891§	85
Northwest Territories	45 741	37 653§	82
Yukon Territory	23 153	21 238§	92
Canada total	24 343 181	19 460 823	80‖

*Statistics Canada (1982f,q).
†CBCL Limited (1984), An Assessment of Municipal Water Supply Infrastructure in the Atlantic Provinces.
‡D. Lacelle (personal communication).
§1981 MUNDAT (Environment Canada, 1981a).
‖ According to 1981 MUNDAT, 20 275 786, or 84% of the Canadian population, was served by municipal distribution networks.

Table 2. Estimated Number of Municipalities on Distribution Networks Obtaining their Entire or Partial Water Supply from Ground-Water Sources, 1981

Region, province or territory	Municipalities <10 000		Municipalities from 10 000 to 100 000		Municipalities >100 000		Total		
	Total No. of municipalities	No. of municipalities reliant on ground water	Total No. of municipalities	No. of municipalities reliant on ground water	Total No. of municipalities	No. of municipalities reliant on ground water	Total No. of municipalities	No. of municipalities reliant on ground water	Percentage of municipalities reliant entirely or partially on ground water
Atlantic Region	324	87	20	5	1	0	345	92	27
Newfoundland	189	28	6	0	0	0	195	28	14
Prince Edward Island	5	5	1	1	0	0	6	6	100
Nova Scotia	74	15	7	2	1	0	82	17	21
New Brunswick	56	39	6	2	0	0	62	41	66
Quebec Region	961	314	88	13	4	0	1053	327	31
Ontario Region	299	145	85	44	17	1	401	190	47
Prairie Region	480	288	17	3	5	1	502	292	58
Manitoba	164	65	3	0	1	0	168	65	39
Saskatchewan	132	111	6	2	2	1	140	114	81
Alberta	184	112	8	1	2	0	194	113	58
British Columbia Region	96	36	33	6	3	0	132	42	32
North of 60 Region	40	7	1	1	0	0	41	8	20
Northwest Territories	35	2	0	0	0	0	35	2	6
Yukon Territory	5	5	1	1	0	0	6	6	100
Canada total	2200	877	244	72	30	2	2474	951	38

Source: 1981 MUNDAT (Environment Canada, 1981a).

The population served by municipal distribution networks for British Columbia, Manitoba, the Northwest Territories and the Yukon was obtained directly from 1981 MUNDAT data.

Municipalities Reliant on Ground Water

Of an estimated 2474 municipalities on municipal distribution networks, over 950 relied entirely or partially on ground water (Table 2). The majority were municipalities which had populations of less than 10 000. Municipalities were divided into three population categories: (1) served populations of less than 10 000, (2) served populations from 10 000 to 100 000, and (3) served populations of more than 100 000. There were 24 municipalities with served populations of 10 000 or more that relied entirely on ground water. In addition there were eight municipalities with served populations of 10 000 or more that receive more than 50% of their water supply from ground water (Table 3).

Over 90% of the municipalities on distribution networks obtain their water supply from their own wells or surface water intakes. The remaining municipalities obtain their supply by purchasing water from other municipalities. MUNDAT did not specify the source of water supply for the municipalities that purchase their own water; MUNDAT, however, specified the originating municipality. Spot checks indicate that over 95% of these municipalities obtain their supply from surface water. Therefore, the source of supply was not verified for all those municipalities that purchase their water and they were classified as surface water users.

Estimates in Table 2 are compatible with published information for Ontario and Saskatchewan. Just under 50% of Ontario's municipalities relied on ground water in 1981 (Ontario Ministry of Natural Resources, 1984), and approximately 85% of the communities within the Saskatchewan–Nelson Basin in Saskatchewan relied on ground water in 1976 (Prairie Provinces Water Board [PPWB], 1982a).

Municipal Domestic Users Reliant on Ground Water

Table 4 specifies the number of municipal domestic users that relied on ground water and the percentage of these users to the total municipal population. Approximately 2.2 million, or 11% of the municipal domestic users, obtained their water supply from ground water. The percentage ranged from less than 1% in the Northwest Territories to 100% in Prince Edward Island. Appendix A explains how the numbers were derived.

Table 3. Municipalities with a Served Population over 10 000 Reliant on Ground Water for More Than 50% of their Supply

Municipality	Population
Ontario Region	Over 100 000
Kitchener*	
Prairie Region	
Regina, Saskatchewan (38% of water supplied by ground water)	
Ontario Region	Over 50 000 to 100 000
Cambridge*	
Sault Ste. Marie	
British Columbia Region	
Prince George*	
Atlantic Region	10 000 to 50 000
Amherst,* Nova Scotia	
Charlottetown,* Prince Edward Island	
Fredericton,* New Brunswick	
Quebec Region	
Cap-de-la-Madeleine*	
Loretteville	
Val-D'Or*	
Ontario Region	
Ancaster	
Aurora*	
Barrie*	
Halton Hills*	
Kapuskasing*	
Midland*	
Milton*	
Newcastle	
Newmarket*	
Orangeville*	
Simcoe*	
Stratford*	
Waterloo*	
Woodstock*	
Prairie Region	
Lloydminster,* Saskatchewan	
North Battleford, Saskatchewan	
Yorkton,* Saskatchewan	
British Columbia Region	
Abbotsford*	
Matsqui*	
Trail	
Whiterock*	
North of 60 Region	
Whitehorse, Yukon Territory	

*Municipalities with 100% of the water supplied by ground water.

Table 4. Estimated Number of Municipal Domestic Users Reliant on Ground Water, 1981

Region, province or territory	No. of municipal domestic users reliant on ground water	Percentage of municipal domestic users reliant on ground water
Atlantic Region	219 001	18
Newfoundland	16 118	4
Prince Edward Island	33 260	100
Nova Scotia	34 485	7
New Brunswick	135 138	39
Quebec Region	411 621	7
Ontario Region	904 283	12
Prairie Region	364 276	12
Manitoba	47 360	6
Saskatchewan	205 138	33
Alberta	111 778	7
British Columbia Region	296 335	15
North of 60 Region	13 902	24
Northwest Territories	202	1
Yukon Territory	13 700	65
Canada total	2 209 418	11

Annual Total Water Use and Ground-Water Use

Approximately 450 million m^3 (cubic metres) of ground water was used annually by municipal users (Table 5, Fig. 1). This volume represents about 9% of the total water used by municipalities with distribution networks. The methods used to derive the volumes of total water and ground-water use are explained in Appendix A.

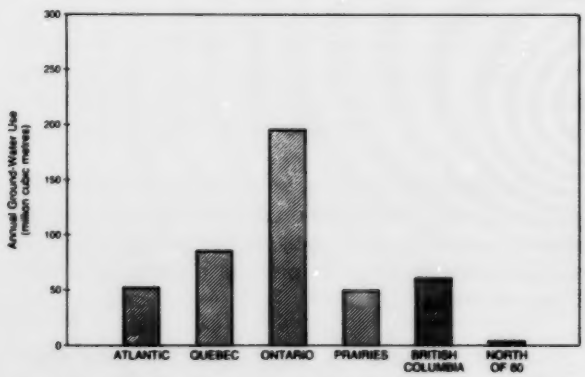

Figure 1. Estimated ground-water use by municipal sector, 1981.

Published information on municipal water use in Ontario states that approximately 11% (or 174 million m^3) of the water used by municipalities in 1981 was obtained from ground water (Ontario Ministry of Natural Resources, 1984). The percentage of ground-water use to total water use in this report is 9%, but in absolute volumes this report indicates a higher volume of ground-water use (198 million m^3). This could be due to the higher ground-water use coefficients in this report.

In a study of the volumes of total water and ground water used by the population in the Saskatchewan–Nelson Basin, the PPWB (1982a) classified their population into urban, rural and farm sectors. Total water and ground water used by these three sectors are compared with total water and ground water used by the municipal and rural sectors in Appendix B.

Discussion

Eighty percent of Canadians were supplied with water from municipal distribution networks in 1981. Thirty-eight percent of the total number of municipalities serving 11% of the municipal population relied on ground water. The number of municipal domestic users reliant on ground water was low because most of these municipalities have small populations, whereas many municipalities reliant on surface water have large populations.

Table 5. Estimated Total Water Use and Ground-Water Use by the Municipal Sector, 1981

Region, province or territory	Total water use ('000 m^3)	Ground-water use ('000 m^3)	Percent of ground-water use to total water use
Atlantic Region	371 120	52 539	14
Newfoundland	103 529	2 369	2
Prince Edward Island	8 481	8 481	100
Nova Scotia	103 545	9 932	10
New Brunswick	155 565	31 757	20
Quebec Region	1 604 120	86 440	5
Ontario Region	1 769 290	198 038	11
Prairie Region	598 923	50 228	8
Manitoba	126 703	5 115	4
Saskatchewan	107 412	27 899	26
Alberta	364 808	17 214	5
British Columbia Region	514 931	60 452	12
North of 60 Region	8 955	3 513	39
Northwest Territories	3 539	19	1
Yukon Territory	5 416	3 494	65
Canada total	4 867 339	451 210	9

The volume of ground water used by municipalities was approximately 9% of total water use. In future studies of municipal water use, a breakdown of ground-water use into domestic, industrial and commercial categories would improve the understanding of ground-water use. One advantage to this type of study would be that the volume of the ground water used by industries on municipal distribution networks could be added to the volume of ground water used by self-supplied industries to give a more accurate estimate of ground-water use by industry.

More complete information on average municipal daily usage and a better breakdown of the volumes of surface water and ground-water use in cases of multiple sources are required. The assumption that annual ground-water usage can be obtained by multiplying municipal daily flows by 365 days merits some investigation, as daily use and source may vary throughout the year.

Information on whether a municipality is on a water metered system would be useful to identify the effect of pricing structure on ground-water use and surface water use. To compute ground-water use and surface water use, a mean annual per capita water use coefficient was calculated for both ground water and surface water. Data for these calculations, however, tend to come from municipalities on metered systems which have complete information on flow rates and served populations. Generally, a municipality that has a metered system uses less water than a municipality without a metered system because of the economic incentive to use less.

RURAL USERS

General

Rural users comprise the balance of the population who are not classified as municipal domestic users. The number of rural users was calculated by taking the difference between the 1981 population and the number of municipal domestic users (Table 1).

Rural users may be on local distribution networks but rely most often on private wells. Individual systems are often used because it is not physically or economically possible to provide a common water supply to these users.

In the context of this report, rural users use water for domestic purposes only. In rare cases where residents have a choice of water supply, ground water is often preferred to surface water, since it is generally better in quality and requires little or no treatment prior to use.

Rural Users Reliant on Ground Water

Approximately 4 million, or 82% of the rural users in Canada, relied on ground water in 1981 (Table 6). In Prince Edward Island, 100% of the rural domestic water supply is obtained from ground water (Inquiry on Federal Water Policy, 1984). Ground water provides the supply for 35% to 40% of the rural users in British Columbia (rough estimate by H. Liebscher, Environment Canada, personal communication), for approximately 50% of the rural users in the Yukon Territory (D. Kittle, Environment Canada, personal communication) and for less than 1% of the rural users in the Northwest Territories (V. Christenson, N.W.T. Government, personal communication). For the other provinces, 90% of total water use by rural users is estimated to be ground water (D. Tate, Environment Canada, personal communication).

Annual Total Water Use and Ground-Water Use

Approximately 280 million m^3 of ground water was used in 1981 by rural users (Table 7, Fig. 2). This volume represents approximately 82% of total water use by these users. The volume of total water use and ground-water use by rural users was calculated by multiplying the number of rural users in each province or territory by an annual per capita water use coefficient. According to the PPWB (1982c), rural farm domestic water use per capita is about 190 L/day, or approximately 70 m^3 annually.

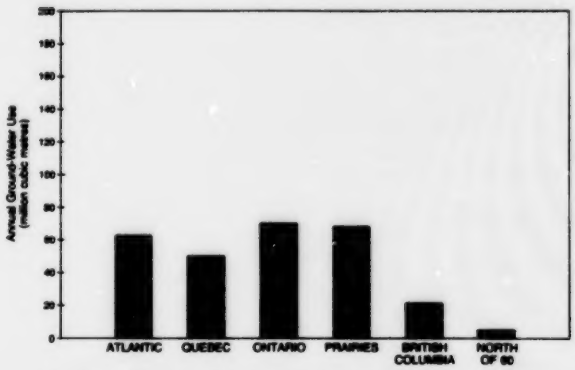

Figure 2. Estimated ground-water use by rural sector, 1981.

Discussion

Approximately 82% of rural users in 1981 relied on ground water. These users are often located in remote areas where it is difficult or economically infeasible to pipe in surface water.

Table 6. Estimated Number of Rural Users Reliant on Ground Water, 1981

Region, province or territory	No. of rural users	No. of rural users reliant on ground water	Percentage of rural users reliant on ground water
Atlantic Region	987 572	897 740	91
Newfoundland	162 481	146 233	90
Prince Edward Island	89 246	89 246	100
Nova Scotia	387 442	348 698	90
New Brunswick	348 403	313 563	90
Quebec Region	793 403	714 663	90
Ontario Region	1 201 107	1 080 996	90
Prairie Region	1 125 396	1 012 857	90
Manitoba	218 959	197 063	90
Saskatchewan	353 313	317 982	90
Alberta	553 124	497 812	90
British Columbia Region	764 877	305 951	40
North of 60 Region	10 003	1 037	10
Northwest Territories	8 088	80	1
Yukon Territory	1 915	957	50
Canada total	4 882 358	4 013 244	82

Table 7. Estimated Total Water Use and Ground-Water Use by the Rural Sector, 1981

Region, province or territory	Total water use ('000 m^3)	Ground-water use ('000 m^3)	Percentage of ground-water use to total water use
Atlantic Region	69 130	62 841	91
Newfoundland	11 374	10 236	90
Prince Edward Island	6 247	6 247	100
Nova Scotia	27 121	24 409	90
New Brunswick	24 388	21 949	90
Quebec Region	55 538	50 026	90
Ontario Region	84 077	75 670	90
Prairie Region	78 778	70 900	90
Manitoba	15 327	13 794	90
Saskatchewan	24 732	22 259	90
Alberta	38 719	34 847	90
British Columbia Region	53 541	21 417	40
North of 60 Region	700	73	10
Northwest Territories	566	6	1
Yukon Territory	134	67	50
Canada total	341 764	280 927	82

Table 8. Comparison of Rural Users to Rural Population, 1981

Region, province or territory	Rural users*	Rural population†
Atlantic Region	987 572	1 036 557
Newfoundland	162 481	234 783
Prince Edward Island	89 246	77 991
Nova Scotia	387 442	380 600
New Brunswick	348 403	343 183
Quebec Region	793 403	1 444 564
Ontario Region	1 201 107	1 578 075
Prairie Region	1 125 396	1 210 908
Manitoba	218 959	295 582
Saskatchewan	353 313	405 147
Alberta	553 124	510 179
British Columbia Region	764 877	605 055
North of 60 Region	10 003	32 095
Northwest Territories	8 088	23 756
Yukon Territory	1 915	8 339
Canada total	4 882 358	5 907 254

*Difference between 1981 Census population and the number of users served by municipal distribution networks (see Table 1).
†Statistics Canada (1982f-q). The term "rural populations" refers to persons living in areas with population concentrations of less than 1000 or population densities of less than 400 per square kilometre (W. Smith, personal communication).

A per capita use rate of 70 m^3 per year (PPWB, 1982c) was used for this study, whereas an International Joint Commission (1981) study for the Great Lakes Basin used a rate of 58 m^3 per year. It is therefore possible that in employing the PPWB coefficient, ground-water use has been overestimated in Ontario. In other parts of Canada it may also be possible that the PPWB coefficient may overestimate or underestimate rural water use. Owing to a lack of coefficients for each of the provinces, the coefficient of 70 m^3/yr was adopted for the purpose of uniformity. To obtain better estimates on rural use, however, it would be necessary to derive coefficients for each of the provinces and territories. Data were not available to compute them.

A comparison between the number of "rural users" as defined in this report and the "rural population" as defined by Statistics Canada (1982f–q) is given in Table 8. This comparison seems to indicate that some rural users are served by a municipal or centralized supply system in provinces such as Ontario and Quebec, whereas a number of users in municipalities in British Columbia obtain their water supply from their own private systems. Additional information on user distribution may enable better estimates of water use in future inventories because rural water use per capita is less than municipal use.

Information on rural non-domestic users, such as recreation sites and small businesses, could improve the estimate on ground-water use in rural areas. These users have not been included in this study.

AGRICULTURAL USERS

General

Agricultural water is defined as water obtained for livestock and/or irrigation use. The quality of the water used for livestock purposes is not known, yet it is probably fairly good. Water quality for irrigation can vary more, but the major limiting factor is a high dissolved solids content.

Annual Total Water Use and Ground-Water Use

On a national scale, ground water represented about 13% (or 404 million m^3) of total water use in the agricultural sector (Table 9, Fig. 3). Data are not available for the two Territories because of lack of significant agricultural activities.

The agricultural water use sector is divided into two subsectors: livestock and irrigation. The next two sections identify the data sources and explain the methods and assumptions used to derive water volumes for these subsectors.

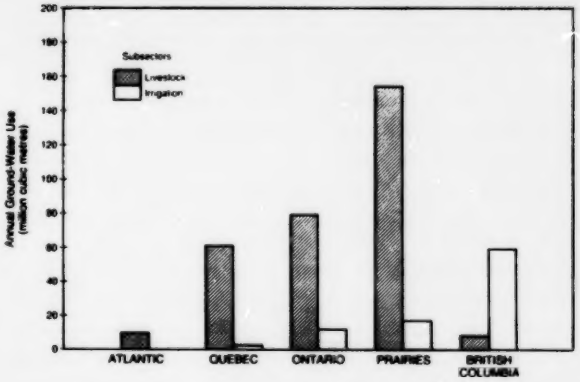

Figure 3. Estimated ground-water use by agricultural sector, 1981. Some values are based on data other than 1981.

Livestock Subsector

The annual total water use and ground water use by livestock in Canada were estimated for 1981. The method to estimate water use by livestock is the same as that used in the PPWB (1982c) study. The PPWB study identified the major categories of livestock and applied a daily water use coefficient for each category (Appendix C, Table C-1). The number of animals in each category for 1981 was obtained from Statistics Canada (1982a) (Table C-2), and the total water used was derived by multiplying these numbers by the appropriate daily water use coefficient.

The exact percentage of water obtained from ground water is unknown. According to the PPWB (1982c) study, "most" of the water for livestock is obtained from ground water. D. Tate (Research Officer, Environment Canada, personal communication) estimates that 90% of the water used for livestock is obtained from ground water for most of Canada. H. Liebscher (Research Officer, Environment Canada, personal communication) roughly estimates that 40% of the water used for livestock watering in British Columbia is ground water.

Irrigation Subsector

Total water use in the provinces where major irrigation takes place was obtained by multiplying the number of irrigated hectares in each province by the respective provincial annual water use coefficient for irrigation (Table C-3). The number of hectares under

Table 9. Estimated Total Water Use and Ground-Water Use by the Agricultural Sector, 1981

Region, province or territory	Livestock subsector			Irrigation subsector*			Total — agricultural		
	Total water use ('000 m³)	Ground-water use ('000 m³)	Percentage of ground-water use	Total water use ('000 m³)	Ground-water use ('000 m³)	Percentage of ground-water use	Total water use ('000 m³)	Ground-water use ('000 m³)	Percentage of ground-water use
Atlantic Region	11 818	10 637	90	—	—	—	11 818	10 637	90
Newfoundland	385	347	90	—	—	—	385	347	90
Prince Edward Island	3 082	2 774	90	—	—	—	3 082	2 774	90
Nova Scotia	4 752	4 277	90	—	—	—	4 752	4 277	90
New Brunswick	3 599	3 239	90	—	—	—	3 599	3 239	90
Quebec Region	68 033	61 230	90	14 224	2 845	20	82 257	64 075	78
Ontario Region	87 781	79 003	90	60 020	12 004	20	147 801	91 007	62
Prairie Region	171 255	154 130	90	2 149 877	17 005	1	2 321 132	171 135	7
Manitoba	31 050	27 945	90	20 874	13 568	65	51 924	41 513	80
Saskatchewan	50 144	45 130	90	261 590	1 570	0.6	311 734	46 700	15
Alberta	90 061	81 055	90	1 867 413	1 867	0.1	1 957 474	82 922	4
British Columbia Region	20 601	8 240	40	524 003	59 155	11	544 604	67 395	12
North of 60 Region	—	—	—	—	—	—	—	—	—
Northwest Territories	—	—	—	—	—	—	—	—	—
Yukon Territory	—	—	—	—	—	—	—	—	—
Canada total	359 488	313 240	87	2 748 124	91 009	3	3 107 612	404 249	13

*Values were derived from 1983 data used for Saskatchewan, 1981 data used for Quebec, 1976 and 1980 data used for Manitoba and Alberta, 1981 and 1980 data used for British Columbia, and 1971 data used for Ontario.

irrigation in 1980 was obtained from Statistics Canada (1982b,d,e) for Manitoba, Alberta and British Columbia; from the provincial Ministry of Agriculture for Quebec in 1981; from Statistics Canada (1971) for Ontario in 1971; and from the Saskatchewan Water Corporation for Saskatchewan in 1983.

Estimates of annual water use and ground-water use were not derived for the Atlantic Region because of the small volumes of water used. According to 1971 Census data (Statistics Canada, 1971), the number of hectares under irrigation in this region is small (less than 2500 ha). Personal communications with the agricultural agencies in each of the provinces indicate that the number of hectares under irrigation has not changed significantly since 1971, although the number of irrigated hectares in Nova Scotia has increased. The agencies agree that 0.1016 m (4 in.) of equivalent rainfall is a reasonable estimate for water used on irrigated land in their provinces. However, they all caution that this value may greatly fluctuate from one year to another.

The water use coefficients for Manitoba, Saskatchewan and Alberta were estimated, based on 1976 data from the PPWB (1982c) study which covered most of the agricultural land in these provinces. The water use coefficient derived for Manitoba was 3010 m^3/ha; for Saskatchewan, 3700 m^3/ha; and for Alberta, 4740 m^3/ha.

The water use coefficient for Ontario was derived from information in a publication by Environment Canada (1979), which states that 0.1491 m (5.87 in.) of equivalent rainfall is used annually on irrigated land in southern Ontario. The water use coefficient is therefore 1491 m^3/ha.

R.S. Broughton, Professor of Agricultural Engineering at MacDonald College of McGill University, suggests that 0.1016 m (4 in.) of equivalent rainfall would be a reasonable estimate for water used on irrigated land in the province of Quebec. Therefore, the water use coefficient for Quebec is 1016 m^3/ha. He cautions, however, that this value may fluctuate with seasonal weather conditions and with the types of crops grown.

The climatic diversity of British Columbia required three water use coefficients. The Province was subdivided into four regions (Statistics Canada, 1982e): (1) Okanagan, (2) Kootenay, (3) Thompson and Caribou, and (4) Mainland, Island and Omineca. The first two regions have dry climates, the third has a moderately dry climate, and the fourth, a wet climate. A number of professionals assisted in providing estimates of rainfall equivalent for irrigation to calculate water use coefficients for these regions. The water use coefficients are 7112 m^3/ha for regions 1 and 2; 4572 m^3/ha for region 3; and 1016 m^3/ha for region 4.

Ground-water use was calculated for each province by multiplying the volume of water use by the percentage estimated to be obtained from ground water. Professionals in the fields of water and agriculture provided or confirmed estimates of ground-water use. The estimates are 20% for Quebec and Ontario (R.S. Broughton, personal communication); 65% for Manitoba (C. Jenkins, Department of Agriculture, Manitoba, personal communication); 0.6% for Saskatchewan (Saskatchewan Water Corporation, personal communication); less than 0.5% for Alberta (Alberta Environment, personal communication); 5% to 20% for British Columbia (Bill Ross, South Okanagan Land Irrigation District; J. Dyck, B.C. Environment; D.S. Stevenson, Agriculture Canada, personal communication).

Discussion

Approximately 88% of the total water use within the agricultural sector was for irrigation. About two thirds of the total water use for irrigation occurred in Alberta. Although ground-water use for irrigation was important (>10%) for some provinces, the percentage for Canada was less than 3% due to the extensive volumes of surface water used in Alberta and Saskatchewan.

Total water use by the livestock subsector represents 12% of the total agricultural water use. The percentage obtained from ground water was high (87%).

Whereas more research would be required to obtain better estimates of total water use and ground-water use in the irrigation subsector, it would be very difficult to obtain precise mean annual volumes because of the fluctuations of weather conditions from year to year. The rotation of crops also adds a variable, since some crops require more water than others. Water use could be monitored if irrigation flows were metered, as in some parts of the United States. In the livestock subsector, total water use may also fluctuate from year to year with changes in the number of livestock.

INDUSTRIAL USERS

General

Industrial water use is defined as water that is self-supplied by industrial plants throughout Canada and by fish enhancement facilities in the Atlantic and British Columbia regions. Industrial water obtained from municipal distribution networks is *not* included in this sector. In this report, the term "industrial users" only refers to industries that obtain their water from a self-supplied source.

Annual Total Water Use and Ground-Water Use

The volume of ground water used by the industrial sector in 1981 was 324 million m^3, which represents 1% of total industrial water use (Tables 10 and 11, Fig. 4). This low percentage is due to the extensive volumes of water supplied from surface sources, particularly in the thermal category. Approximately 44% of the ground water used in the industrial sector was for fish enhancement facilities.

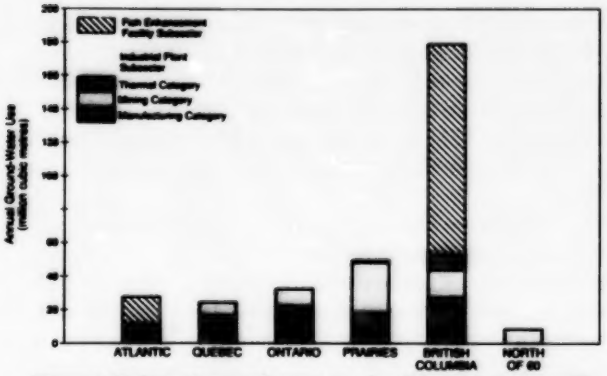

Figure 4. Estimated ground-water use by industrial sector (self-supplied only), 1981. Some Prairie Region values are based on 1976 and 1979 data.

Industrial Plants Subsector

An industry is categorized as being a manufacturing, mining or thermal plant. Table D-1 in Appendix D indicates the types of industries within each of the three categories.

Table 10. Estimated Ground-Water Use by the Industrial Sector (self-supplied only), 1981 ('000 m^3)

Region, province or territory	Industrial plant subsector category users			Fish enhancement facilities subsector	Total
	Manufacturing	Mining	Thermal		
Atlantic Region	7 783	2 634	10	16 892	27 319
Newfoundland	58	1 014	0		1 072
Prince Edward Island	621	0	0	306	927
Nova Scotia	4 392	1 604	0	850	6 846
New Brunswick	2 712	16	10	15 736	18 474
Quebec Region	16 466	8 799	0		25 265
Ontario Region	22 153	10 901	0		33 054
Prairie Region	18 413	31 152	130		49 695
Manitoba	10 527	0	130		10 657
Saskatchewan*	1 586	14 427	0		16 011
Alberta†	6 302	16 725	0		23 027
British Columbia Region	27 231	16 909	9310	126 400	179 850
North of 60 Region	0	9 168	0		9 168
Northwest Territories	0	9 168	0		9 168
Yukon Territory	0	0	0		0
Canada total	92 046	79 563	9450	143 292	324 351

*Includes data from 1976.
†Includes data from 1979.

Source: Environment Canada (1981b).

Table 11. Estimated Total Water Use by the Industrial Sector (self-supplied only), 1981 ('000 m³)

Region, province or territory	Industrial plant subsector category users			Fish enhancement facilities subsector*	Total
	Manufacturing	Mining	Thermal		
Atlantic Region	523 148	84 862	1 797 130	16 892	2 422 032
	(1%)†	(3%)	(<1%)	(10%)	(1%)
Newfoundland	76 221	58 254	76 750		211 225
	(<1%)	(2%)	(0%)		(1%)
Prince Edward Island	2 129	0	700	306	3 135
	(29%)	(0%)	(0%)	(100%)	(30%)
Nova Scotia	223 376	11 418	915 350	850	1 150 994
	(2%)	(14%)	(0%)	(100%)	(1%)
New Brunswick	221 422	15 190	804 330	15 736	1 056 678
	(1%)	(<1%)	(<1%)	(100%)	(2%)
Quebec Region	2 113 427	76 042	307 690		2 497 159
	(<1%)	(12%)	(0%)		(1%)
Ontario Region	4 147 215	114 162	14 924 310		19 185 687
	(<1%)	(10%)	(0%)		(<1%)
Prairie Region	340 402	216 641	1 817 940		2 374 983
	(5%)	(14%)	(<1%)		(2%)
Manitoba	84 481	12 706	55 570		152 757
	(12%)	(0%)	(<1%)		(7%)
Saskatchewan‡	36 565	36 139	766 010		838 714
	(4%)	(40%)	(0%)		(2%)
Alberta§	219 356	167 796	996 360		1 383 512
	(3%)	(10%)	(0%)		(2%)
British Columbia Region	2 126 504	119 837	358 180	126 400	2 730 926
	(1%)	(14%)	(3%)	(100%)	(7%)
North of 60 Region	879	24 406	0		25 285
	(0%)	(38%)			(36%)
Northwest Territories	875	14 032	0		14 907
	(0%)	(65%)			(62%)
Yukon Territory	4	10 374	0		10 378
	(0%)	(0%)			(0%)
Canada total	9 251 580	635 950	19 205 250	143 292	29 236 072
	(1%)	(12%)	(<0.1%)	(100%)	(1%)

*The percent of ground-water use to total water use cannot be determined, since the volume of surface water used is not known. The difficulty in making a comparison is that surface water is an instream use and is not withdrawn.
†Values in parentheses represent the percentage of water that is obtained from ground water.
‡Includes data from 1976.
§Includes data from 1979.

Source: Environment Canada (1981b).

Estimates of total water use (Table D-2) and ground-water use (Table D-3) were obtained primarily from a 1981 industrial water use survey (Environment Canada, 1981b). The 1976 and 1979 data for oil well injection schemes obtained from the PPWB (1982b) study were used to supplement the data in the mining component of the 1981 industrial water use survey for Saskatchewan and Alberta, respectively.

The 1981 industrial water use survey was based on a nationwide survey done jointly by Environment Canada and Statistics Canada. Approximately 7000 survey questionnaires were sent out to major[1] industrial water users in Canada. Of the 7000 questionnaires, 5600 were returned, 386 of which indicated ground-water use. These major industrial plants were located at 304 sites, many of them within munici-

[1]In 1972, a more comprehensive survey found that many respondents used very little water. Consequently, the 1981 questionnaires were sent out only to the industries using larger volumes of water (Tate, personal communication).

palities. D. Tate (personal communication) estimates that these surveyed users represent about 90% of the water use by industrial sources. An estimated 33 000 remaining industries from a total of approximately 40 000 (Tate, personal communication) are relatively small users or they are connected to a municipal water distribution network.

The 1981 survey attempted to survey water use for petroleum and natural gas production and processing. The response represents the water used in natural gas processing but not the water used for oil well injection schemes. Hence the PPWB (1982b) study was used to obtain data on this subcategory for Alberta and Saskatchewan.

The PPWB (1982b) study indicated total water use and ground-water use for oil well injection in Alberta to be 29.503 and 7.306 million m^3, respectively, for 1979. These unadjusted 1979 values have been added in the mining category for Alberta in this report.

The PPWB (1982b) study indicated total water use and ground-water use in crude petroleum (includes oil well injection) and natural gas processing in Saskatchewan to be 10.7 and 10.3 million m^3, respectively, in 1976. These values were significantly higher than the values given in the 1981 industrial water use survey (0.063 million m^3 and 0). Consequently, the unadjusted 1976 results from the crude petroleum and natural gas processing subcategory were used in place of the 1981 results for the mining category.

Table 12. Percentage of Water Used by Industrial Users (self-supplied only) Containing <1000 mg/L of Dissolved Solids

Region, province or territory	Ground-water use 1981	Total water use 1981
Atlantic Region	99	22
Newfoundland	100	53
Prince Edward Island	100	40
Nova Scotia	99	11
New Brunswick	97	28
Quebec Region	99	99
Ontario Region	98	99
Prairie Region	99	99
Manitoba	99	99
Saskatchewan*	100	99
Alberta†	99	99
British Columbia Region	99	99
North of 60 Region	100	100
Northwest Territories	100	100
Yukon Territory	—	100
Canada total	99	93

*Values do not include water used for oil injection wells and natural gas processing.
†Values do not include water used for oil injection wells.

Source: Environment Canada (1981b).

The 1981 industrial water use survey also provided information on the quality of the water used. Because some industries do not require the same high quality water required by others, low-grade water, including brackish water,[2] can be used for industrial purposes. Table 12 indicates the percentage of fresh water use to total water use, based on data from the 1981 industrial water use survey only. The PPWB (1982b) study did not provide a breakdown of fresh to brackish water use.

Fish Enhancement Facilities Subsector

In British Columbia, New Brunswick, Nova Scotia and Prince Edward Island, large volumes of ground water are used for salmon and trout enhancement programs. In Quebec, ground water is also used for this purpose, but figures are not available.

Ground water is used because it has a nearly constant temperature, which is essential to the survival of the fish. Surface water is also used, but in the context of this report it has not been included in the calculations of surface water use because it is an instream use where water is not withdrawn.

In British Columbia, approximately 50 enhancement facilities are operated by the federal Department of Fisheries and Oceans, by the Provincial Fish and Wildlife Branch and by commercial trout rearing farms. Liebscher (personal communication) estimates that the volumes of ground water (in cubic metres per year) used in 1981 by the three types of fish enhancement facilities were the following:

Fisheries and Oceans	107 200 000
Provincial Fish and Wildlife	15 000 000
Commercial	4 200 000
Total	126 400 000

[2]Brackish water in the context of the industrial survey is water containing >1000 mg/L of dissolved solids.

In the Atlantic Region (excluding Newfoundland) nine enhancement facilities are operated by either the federal Department of Fisheries and Oceans or provincial agencies (F. Cruickshank, Research Officer, Environment Canada, personal communication). Groundwater volumes used by the commercial sector were not available. The volume of ground water (in cubic metres per year) used in 1981 is listed below by province.

Nova Scotia	850 000
Prince Edward Island	306 000
New Brunswick	15 736 000
Total	16 892 000

The volume of ground-water use has been incorporated into the water use tabulations, but the locations of these facilities have not been plotted on the regional maps.

Discussion

The volume of ground-water use by the industrial sector in Canada is comparable to that in the other three sectors. The largest portion of the ground water was used by the fish enhancement facilities, followed by the manufacturing and mining categories within the industrial plant subsector. Ground-water use is not significant in the thermal category in Canada, except in British Columbia, where it does have some significance, although it is quite low.

Within fish enhancement facilities, ground water is extremely important. In the industrial plant subsector, the relative importance of ground water ranges from less than 1% to 12%. Nationally, 12% of the water used in the mining category is ground water; the figure is 1% for the manufacturing category and significantly less than 1% for the thermal category. Because of the extensive volume of surface water use by users in the thermal category, ground-water use at the national scale represents about 1% of the total use. In most parts of Canada, the magnitude of ground-water use in the industrial sector is low. Ground water in the Northwest Territories, however, is important and represents 62% of total use.

Most of the water used in the industrial sector was fresh, although some brackish water is used, particularly in the Atlantic Region. The demonstrated use of brackish water in the Atlantic Region indicates that there is potential use for brackish ground water elsewhere in Canada.

Estimates in this sector could be improved if the Industrial Water Use Survey included the smaller industrial users on self-supplied water systems. It is probable that smaller industrial users, similar to smaller municipalities, rely more on ground water than do the larger industries.

SUMMARY

Population Reliant on Ground Water

Approximately 6.2 million, or 26% of Canadians, relied on ground water as their primary source of domestic water supply in 1981 (Table 13). About two thirds of this population were rural users (Fig. 5).

Table 13. Estimated Population (municipal domestic users and rural users) Reliant on Ground Water, 1981

Region, province or territory	Population reliant on ground water	Percentage of population reliant on ground water
Atlantic Region	1 116 741	50
Newfoundland	162 351	29
Prince Edward Island	122 506	100
Nova Scotia	383 183	45
New Brunswick	448 701	64
Quebec Region	1 126 284	17
Ontario Region	1 985 279	23
Prairie Region	1 377 134	33
Manitoba	244 423	24
Saskatchewan	523 120	54
Alberta	609 541	27
British Columbia Region	602 286	22
North of 60 Region	14 939	22
Northwest Territories	282	1
Yukon Territory	14 657	63
Canada total	6 222 663	26

Regionally, 50% of the population in the Atlantic Region relied on ground water; in the Prairie Region, 33%; in the Ontario Region, 28%; in the British Columbia Region, 22%; in the North of 60 Region, 22%; and in the Quebec Region, 17%. Provincially, the entire population of Prince Edward Island relied on ground water, while over half of the people relied on ground water in New Brunswick, the Yukon Territory and Saskatchewan. In the other provinces, 17% to 45% of the population relied on ground water, and in the North-

west Territories, less than 1% of the population relied on ground water.

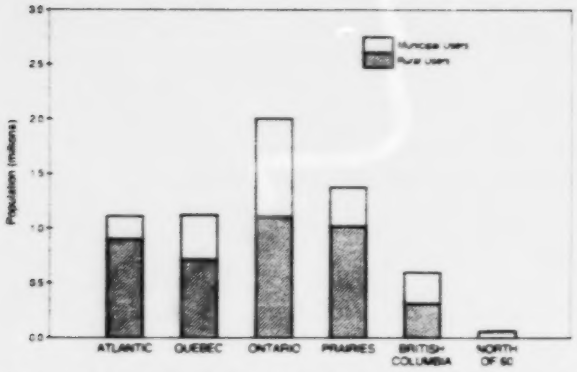

Figure 5. Estimated population reliant on ground water, 1981. Some values are based on 1983 data.

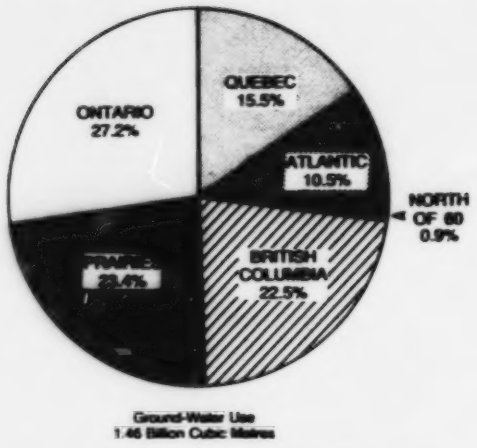

Figure 7. Estimated ground-water use by region, 1981.

Ground-Water Use

Approximately 1.46 billion m^3 of ground water was used in Canada during 1981. Nationally, the largest ground-water user was the municipal sector (31%), followed by the agricultural (28%), industrial (22%) and rural (19%) sectors (Table 14, Fig. 6). However, the sector that relied most on ground water varied from region to region. In the Ontario and Quebec regions, the largest ground-water user was the municipal sector; in the Prairie Region, agricultural; in the Atlantic Region, rural; and in the British Columbia and North of 60 regions, industrial. Regionally, the largest volumes of ground water were used (Fig. 7) in Ontario (27%), the Prairie Region (23%) and British Columbia (23%).

Comparison of Ground-Water Use to Total Water Use

During 1981, over 37.552 billion m^3 of water was used in Canada (Table 15). Approximately 51% of this use was by the thermal category of the industrial sector (Fig. 8). Because of the large volume of water used by the thermal category within the industrial sector, calculations of ground-water use to total water use have been done twice (Table 16); one includes thermal water use, the other excludes thermal water use. The percentage of total water obtained from ground water was 4% if thermal water use had been included, and 8% if thermal water had been excluded. The percentage of total water use obtained from ground water regionally ranged from 2% to 37% and provincially, from 6% to 88% (thermal water use

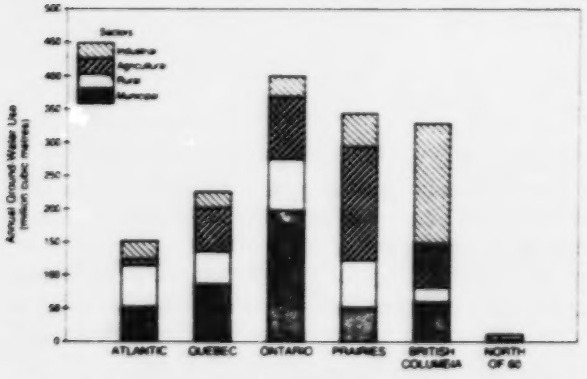

Figure 6. Estimated ground-water use in Canada by region, 1981. Some values are based on data obtained from other years.

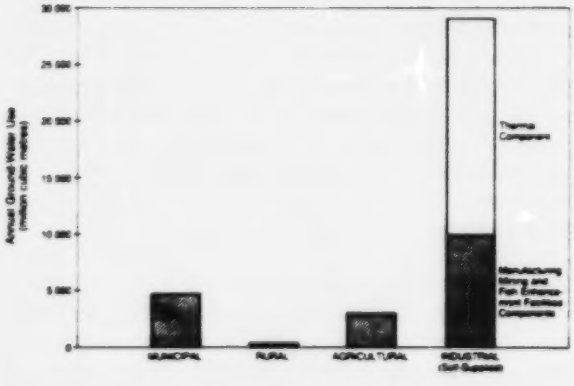

Figure 8. Estimated total water use in Canada by sector, 1981. Some values are based on data other than 1981.

included). Ground water is of extreme importance to Prince Edward Island (88% of total use) and is important in the North of 60 Region (37% of total use).

The relative importance of ground water in Canada may be greatly overlooked if the reader just glances at the figures on Table 16. Because of the great volumes of surface water use by the industrial plant subsector, the irrigation subsector and the larger municipalities, the relative importance of ground water is reduced. Ground water, however, is important to the rural sector, the livestock subsector, fish enhancement facilities and small municipalities. Without ground water, it is possible that economic or physical restraints would restrict or even prohibit industrial and commercial development, particularly in remote areas. The use of ground water for farming often reduces costs, since it is usually more cost efficient to drill a well than to pipe in surface water. Ground water is extremely important in the rural areas, particularly on farms, since most of this population relies on it.

REGIONAL MAPS

The geographic distribution of aquifers and the distribution of ground-water users for the municipal and industrial sectors are shown on the six regional maps (in pocket). Five regional maps covering the ten provinces are drawn at a scale of 1:4 million, and a regional map covering the two Territories is drawn at 1:8 million. The following subsections identify the data sources and limitations for the information on aquifers and ground-water users.

Aquifers

The aquifers on the regional maps were derived from information in reports prepared by MLM Ground-Water Engineering (1979; 1981a,b) for the National Research Council and in the *Hydrological Atlas of Canada* (Fisheries and Oceans, 1978). The sources have incomplete information, such as unknown yield rates for some areas. In some cases,

Table 14. Estimated Ground-Water Use in Canada, 1981*

Region, province or territory	Annual ground-water use ('000 m³)	Percentage of use by sector			
		Municipal	Rural	Agricultural	Industrial (self-supplied only)
Atlantic Region	153 336	34	41	7	18
	(153 326)†	(34)	(41)	(7)	(18)
Newfoundland	14 024	17	73	2	8
Prince Edward Island	18 429	46	34	15	5
Nova Scotia	45 464	22	54	9	15
New Brunswick	75 419	42	29	4	25
	(75 409)	(42)	(29)	(4)	(25)
Quebec Region	225 806	38	22	29	11
Ontario Region	397 769	51	18	23	8
Prairie Region	341 958	15	21	50	14
	(341 828)	(15)	(21)	(50)	(14)
Manitoba	71 079	7	19	59	15
	(70 949)	(7)	(19)	(59)	(15
Saskatchewan	112 869	25	20	41	14
Alberta	158 010	11	22	52	15
British Columbia Region	329 114	18	7	20	55
	(319 804)	(19)	(7)	(21)	(53)
North of 60 Region	12 754	27	1	0	72
Northwest Territories	9 193	<1	<1	0	99
Yukon Territory	3 561	98	2	0	0
Canada total	1 460 737	31	19	28	22
	(1 451 287)	(31)	(19)	(28)	(22)

*Some values not totally based on 1981 data. Refer to Agricultural and Industrial User sections for details in this report.
†Numbers in parentheses represent values which exclude ground-water use by the thermal category within the industrial sector.

Table 15. Estimated National Total Water Use by Sector, 1981*

Sector users	Column A Water use including thermal water use within the industrial sector (self-supplied only) ('000 m^3)	Column B Water use excluding thermal water use within the industrial sector (self-supplied only) ('000 m^3)
Municipal	4 867 339	4 867 339
Rural	341 764	341 764
Agricultural	3 107 612	3 107 612
Industrial	29 235 237	10 029 987
Total	37 552 787†	18 347 537

*Some values not based totally on 1981 data. See Agricultural and Industrial User sections for details in this report.
†According to Tate (Environment Canada, 1985), 37 518 × 10^6 m^3 of water was used in 1981.

Table 16. Estimated Total Water Use in Canada and the Percentage Obtained from Ground Water, 1981*

Region, province or territory	Total water use including thermal water use ('000 m^3)	Percentage from ground water	Total water use excluding thermal water use ('000 m^3)	Percentage from ground water
Atlantic Region	2 874 100	5	1 076 970	14
Newfoundland	326 513	4	249 763	6
Prince Edward Island	20 945	88	20 245	91
Nova Scotia	1 286 412	4	371 062	6
New Brunswick	1 240 230	6	435 900	17
Quebec Region	4 239 074	5	3 931 384	6
Ontario Region	21 186 855	2	6 262 545	6
Prairie Region	5 373 816	6	3 555 876	10
Manitoba	346 711	20	291 141	24
Saskatchewan	1 282 592	9	516 582	22
Alberta	3 744 513	4	2 748 153	6
British Columbia Region	3 844 002	9	3 485 822	9
North of 60 Region	34 940	37	34 940	37
Northwest Territories	19 012	48	19 012	48
Yukon Territories	15 928	22	15 928	22
Canada total	37 552 787†	4	18 347 537	8

*Values not totally based on 1981 data. Refer to Agricultural and Industrial User sections for details.
†According to Tate (Environment Canada, 1985), 37 518 × 10^6 m^3 of water was used in 1981.

yield rates were estimated from geologic formations rather than from field measurements. The scale of the aquifer maps for Ontario was for southern Ontario 1:1 million and for northern Ontario, 1:2 million (MLM Ground-Water Engineering, 1981b); for the Prairie Provinces, 1:2 million (MLM Ground-Water Engineering, 1979); and for the Atlantic Provinces, 1:1 million (MLM Ground-Water Engineering, 1981a) excluding the Labrador portion of Newfoundland. The Atlas presents maps at a scale of 1:10 million for all of Canada. The Atlas information was only used for the regions not covered by the MLM reports (Quebec, British Columbia, Northwest Territories, Yukon Territory and the Labrador portion of Newfoundland).

The same ranges of yield for the aquifers were not used in all the reports. In the MLM reports, aquifer yield rates (in litres per second) were grouped as follows:

Atlantic and Prairie provinces	0.4–1.9
	>1.9
Ontario	0.4–1.9
	1.9–7.6
	>7.6

The aquifer yields in the Atlas were grouped as follows: (1) 0.5 L/s to 2.0 L/s, (2) 2.0 L/s to 8.0 L/s, and (3) >8 L/s.

To simplify presentation on the maps in this report, all aquifers with yields greater than 0.4 L/s (Ontario, Prairie Provinces, Atlantic Provinces excluding the Labrador portion of Newfoundland) or greater than 0.5 L/s (Quebec, British Columbia, the two Territories and the Labrador portion of Newfoundland) are shown. Furthermore, although surficial and bedrock aquifers were mapped separately in the MLM reports and the Atlas, this report does not differentiate between the two.

The water quality from aquifers varies throughout Canada. The quality ranges from being potable (less than 1000 mg/L) to water containing up to 5000 mg/L of dissolved solids. Rarely, water may contain more than 25 000 mg/L of dissolved solids.

In a few cases on the maps, ground water seems to be obtained from areas without aquifers. There are two possible explanations: first, the aquifer is too small to be shown on the map or second, the reported volume is obtained from a number of wells in a low-yielding aquifer (i.e. yield rate of less than 0.4 L/s) over a large area.

Ground-Water Users

The six regional maps (in pocket) indicate the spatial distribution and the annual volumes of ground water used by municipal and industrial users (fish enhancement facilities are not shown on the maps). Owing to the lack of information, it was not possible to map agricultural and rural domestic water usage. To evaluate the relative magnitude of ground-water use by each sector, a pie diagram showing the regional breakdown of annual ground-water use by sector has been included on each map.

Municipal[3] and industrial ground-water users[4] are shown on the maps red circles and squares, respectively. The volume[5] of annual ground-water use represented by the size of the symbols has been grouped into six classes:

(1) Up to and including 100 000 m^3
(2) 100 001 to 500 000 m^3
(3) 500 001 to 1 000 000 m^3
(4) 1 000 001 to 5 000 000 m^3
(5) 5 000 001 to 10 000 000 m^3
(6) Greater than 10 000 000 m^3

A small star represents values of unknown municipal ground-water use.

CONCLUSIONS

Major Findings of Inventory Report

Ground water is an important renewable resource in Canada, supplying many people and institutions which might not be able to obtain other sources of water. The major findings of this inventory report are the following:

(1) Approximately 1.46 billion m^3 of ground water was used in 1981. Nationally, the sector that used

[3]1981 MUNDAT data were used on the regional maps to plot the number of municipalities that rely on ground water. Of the 951 municipalities listed in Table 2, 907 have been plotted. The 44 municipalities (Atlantic, 2; Quebec, 31; Ontario, 8; Prairies, 3) were omitted due to inconsistent data. In British Columbia, 10 communities were added, although by definition they are not classified as municipalities (H. Liebecher, personal communication, British Columbia Ministry of the Environment, 1978).

[4]The locations of some of the users had to be approximated because generalizations were made in the original data, i.e., township or census divisions were given instead of exact locations.

[5]Approximately 20% of the volumes of the municipalities were estimated (served population of municipality × ground-water use coefficient).

the largest volume of ground water was the municipal (31%), followed by the agricultural (26%), the industrial (22%) and the rural (19%).

Regionally, the breakdown is much different. In the Atlantic Region the largest user was the rural sector; in the Quebec and Ontario regions, the municipal; the Prairie Region, the agricultural; in the British Columbia Region, the industrial sector; and in the North of 60 Region virtually all the ground water used in the Yukon Territory was used by the municipal sector, whereas in the Northwest Territories virtually all the ground water was used by the industrial sector.

Ground water was used throughout Canada. The largest volume of use occurred in the Ontario Region (27.2%), followed by Prairie Region (23.4%), British Columbia Region (22.5%), Quebec Region (15.5%), Atlantic Region (10.5%), and the North of 60 Region (0.9%).

(2) Approximately 4% of total water use in Canada was obtained from ground water. However, if water use by the thermal category within the industrial sector was excluded from the calculations, ground-water use accounted for about 8% of the total water use.

Regionally, the North of 60 Region relied on ground water for 37% of its total water use (no water was used for thermal purposes). In the other regions, the percentage of total water use obtained from ground water ranged from 2% (Ontario) to 9% (British Columbia) if thermal water use was included, and from 6% (Ontario) to 14% (Atlantic) if thermal water use was not included.

In Prince Edward Island and the Northwest Territories, ground water represented 91% and 48%, respectively, of total water use (thermal water use not included). In the other provinces and the Yukon Territory, ground water represented from 6% (Newfoundland, Nova Scotia, Quebec, Ontario and Alberta) to 22% of total water use if thermal water use was not included.

(3) In 1981, approximately 6.2 million, or 26% of Canadians, relied on ground water for domestic purposes. Regionally, the percentage of the population that relied on ground water ranged from 17% (Quebec Region) to 50% (Atlantic Region).

Provincially, the percentage of the population relying on ground water ranged from 17% in Quebec to 100% in Prince Edward Island, while in the territories, the percentages were 63% for the Yukon Territory and 1% for the Northwest Territories.

Nationally, about two thirds of the population relying on ground water for domestic purposes were rural users and one third were municipal users. Ground water was of particular importance to the rural users, since approximately 82% of them relied on ground water as their source of domestic supply.

(4) Approximately 38% of municipalities in Canada relied entirely or partially on ground water. Most of these municipalities were small, with populations of less than 10 000; there were, however, municipalities of 100 000 or more (Regina, Kitchener) that relied entirely or partially on ground water. Regionally, the percentage of municipalities that relied on ground water as their source of supply ranges from 20% in the North of 60 Region to 58% in the Prairie Region. Provincially and territorially, ground water was used as a source of water supply for most municipalities in Prince Edward Island (100%), the Yukon Territory (100%), Saskatchewan (81%), New Brunswick (66%) and Alberta (58%). In the other provinces, municipalities that relied on ground water ranged from 14% (Newfoundland) to 47% (Ontario). In the Northwest Territories, 6% of the municipalities relied on ground water.

(5) Approximately 87% of the water used for livestock was obtained from ground water. Regionally, this percentage ranged from 40% in the British Columbia Region to 90% in the balance of the regions (excluding the North of 60 Region where no significant water use for livestock occurred).

Ground-water use for irrigation purposes represented about 3% of total water use. This low value was due to the extensive volumes of surface water use in Alberta and Saskatchewan. Regionally, ground water for irrigation represented from 1% (Prairie Region) to 20% (Quebec and Ontario regions) of total water use. The only province where ground water represented most of the total supply for irrigation was in Manitoba (65%).

(6) The percentage of water supplied from ground water in the industrial sector was about 1%. This low percentage was mainly due to the extensive volumes of surface water used by the thermal component, and to a lesser extent, the manufacturing component of this sector. Regionally, the percentage of ground-water use in relation to total water use in the industrial sector ranged from less than 1% in the Ontario Region to 36% in the North of 60 Region.

Of the four components that comprise the industrial sector, the largest user of ground water was the fish enhancement facilities component, followed by the manufacturing, mining and thermal components.

Ground water was important for fish enhancement facilities in the Atlantic Region, British Columbia Region and possibly the Quebec Region. Ground water was important for mining in the Northwest Territories (65% of total use).

Ground water is potentially available to many areas in Canada, as much of the country is underlain with aquifers. However, yield rates and quality of the water in many areas are not known.

Data Deficiencies

Estimates on ground-water use were made from available data. Within this report deficient information is identified or is self-evident. Nevertheless, it is important to realize that significant improvements can be made in the rural and agricultural sectors.

Required Work

As the importance of ground water is recognized, an assessment of this resource and its use will be required for rational development and management of aquifers. To realize such an assessment, cooperation between different levels of government as well as major time and money commitments will be necessary. These costs will have to be weighed against the benefits obtained.

Consideration should be given to conducting the following activities to improve information on ground-water use:

(1) Collect ground-water use data at intervals of 5 to 10 years to identify trends.

(2) Encourage the use of metering systems, particularly for municipal users and agricultural irrigation.

(3) Conduct surveys, for example for rural domestic and livestock uses, when metering is not possible.

(4) Refine estimates from existing surveys by obtaining complete information on volumes of surface water and ground-water use when multiple sources of supply are used and by separating municipal water use into domestic and industrial categories.

(5) Refine estimates by incorporating small users such as greenhouses, irrigated golf courses, rural commercial establishments and users of ground-water heat pumps.

Two major benefits to ensue from complete data on ground-water use would be the following:

(1) Better management of our ground-water resources. By examining trends, one could anticipate the depletion of ground-water resources in an area and prevent this depletion by proper aquifer management. Cost savings for communities, industries and individuals could be realized by maintaining the ground-water resources instead of developing more expensive alternatives. Economic expansion of a community or region could be encouraged if trends indicate an acceptable level of ground-water use.

(2) Identification of critical areas for aquifer protection. The identification of major use areas may enable governments to enact aquifer protection measures to maintain the integrity of the water supply.

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Appendix A
Municipal Section

APPENDIX A

MUNICIPAL SECTION

INTRODUCTION

The populations served, sources of water supply, and the average daily flows were given for most of the municipalities served by municipal water distribution networks in Environment Canada's (1981) *National Inventory of Municipal Waterworks and Wastewater Systems in Canada, 1981* (1981 MUNDAT).

MUNICIPAL DOMESTIC USERS

The number of municipal domestic users reliant on ground water was obtained by summing for each province and territory the served populations of each municipality using ground water (Table A-1). The number of municipal users reliant on surface water (Table A-2) was calculated by taking the difference between the number of municipal domestic users reliant on ground water (Table A-1) and the total number of municipal domestic users (Table 1).

About 5% to 10% of the municipalities obtain their water supply by purchasing water from other municipalities or private organizations. The origin (ground or surface) of the supply for these municipalities is not clearly stated, but often it was possible to determine the source by cross-referencing to the municipality providing the water supply. A rough check on MUNDAT data indicated that over 95% of these municipalities obtained their supply indirectly from surface water sources. Therefore, in this report, municipal users reliant on purchased water were classified as surface water users.

Approximately 5% to 10% of the municipalities use both ground water and surface water. In these situations, the number of ground and surface users was prorated according to the percentage of the water obtained from each source. Although this method provided an estimate of the number of ground-water and surface water users, in reality these users cannot be separated. In some municipalities (e.g. Regina, Whitehorse) ground-water and surface water sources may be used on a seasonal basis or ground water may supplement a surface water supply during peak water demand periods. Therefore ground water may be of extreme importance to the entire municipality during critical seasons and not be used at all at other times of the year.

When it was not possible to get a breakdown of surface and ground water use in a municipality, it was assumed that the water was obtained from a surface source.

VOLUME OF ANNUAL GROUND-WATER AND SURFACE WATER USE BY MUNICIPAL USERS

To calculate the volume of ground-water use (Table A-4) for each province and territory, the number of ground-water users was multiplied by an average per capita ground-water use coefficient (Table A-3). Similarly, surface water use (Table A-5) was calculated by multiplying the number of surface water users by an average per capita surface water use coefficient (Table A-3).

Table A-1. Estimated Number of Municipal Domestic Users Reliant on Ground Water, 1981

Province or Territory	Number of users
Newfoundland	16 118
Prince Edward Island	33 260
Nova Scotia	34 485
New Brunswick	135 138
Quebec	411 621
Ontario	904 283
Manitoba	47 360
Saskatchewan	205 138
Alberta	111 778
British Columbia	296 335
Northwest Territories	202
Yukon Territory*	13 700

*1981 data from Whitehorse used to provide breakdown of surface and ground-water use (B. St. Amand, Utilities Technologist, City of Whitehorse, personal communication).

Table A-2. Estimated Number of Municipal Domestic Users Reliant on Surface Water

Province or Territory	Number of users
Newfoundland	389 082
Prince Edward Island	0
Nova Scotia	425 515
New Brunswick	212 862
Quebec	5 233 379
Ontario	6 519 717
Manitoba	759 922
Saskatchewan	409 862
Alberta	1 572 822
British Columbia	1 683 255
Northwest Territories	37 451
Yukon Territory	7 538

Table A-3. Estimated Annual Per Capita Water Use Coefficients (m^3/yr)

Province or Territory	Annual per capita ground-water use coefficient*	Annual per capita surface water use coefficient†
Newfoundland	147	260
Prince Edward Island	255	—
Nova Scotia	288	220
New Brunswick	235	607 (228)‡
Quebec	210	290
Ontario	219	241
Manitoba	108	160
Saskatchewan	136	194
Alberta	154	221
British Columbia	204	270
Northwest Territories	94§	94
Yukon Territory	255‖	255‖

*Annual ground-water use coefficients were obtained by dividing:

$$\frac{\text{total annual ground-water flow rates for all municipalities}}{\text{total served population of these municipalities}}$$

Only municipalities with complete information on both flow rates and served populations were incorporated into the calculations.

†Annual surface water use coefficients were obtained by dividing:

$$\frac{\text{total annual surface water flow rates for all municipalities}}{\text{total served population of these municipalities}}$$

Only municipalities with complete information on both flow rates and served populations were incorporated into the calculations.

‡The computed per capita water use coefficient for New Brunswick is 607 m^3/yr. This high value is due to extensive water use for industrial purposes in Saint John (water use coefficient is 1485 m^3/yr per capita). The 607 m^3/yr per capita coefficient was used for 198 615 residents in municipalities where both served populations and flow rates were known. The 228 m^3/yr per capita coefficient (excludes Saint John) was used to determine the water use for the 14 247 residents in municipalities whose flow rates were not known.

§Surface water use coefficient.

‖ Whitehorse annual per capita water use coefficient.

Source: 1981 MUNDAT (Environment Canada, 1981a). All data in this source provided daily use. All numbers were multiplied by 365 (days) to provide annual use.

Table A-4. Estimated Volume of Ground-Water Use by Municipalities, 1981 ('000 m³)

Province or Territory	Ground-water use
Newfoundland	2 369
Prince Edward Island	8 481
Nova Scotia	9 932
New Brunswick	31 757
Quebec	86 440
Ontario	198 038
Manitoba	5 115
Saskatchewan	27 899
Alberta	17 214
British Columbia	60 452
Northwest Territories	19
Yukon Territory*	3 494

*1981 data from Whitehorse (B. St. Amand, City of Whitehorse, personal communication).

Table A-5. Estimated Volume of Surface Water Use by Municipalities, 1981 ('000 m³)

Province or Territory	Surface water use
Newfoundland	101 160
Prince Edward Island	0
Nova Scotia	93 613
New Brunswick	123 808
Quebec	1 517 680
Ontario	1 571 252
Manitoba	121 588
Saskatchewan	79 513
Alberta	347 594
British Columbia	454 479
Northwest Territories	3 520
Yukon Territory	1 922

Appendix B

Total Water and Ground-Water Use in the Prairie Provinces

APPENDIX B

TOTAL WATER AND GROUND-WATER USE IN THE PRAIRIE PROVINCES

PRAIRIE PROVINCES WATER BOARD STUDY

The PPWB (1982a) study on the Saskatchewan–Nelson Basin classified the population of water users into three categories (subsectors):

(1) Urban (population in centres of 1000 people or more)

(2) Rural (population in small centres and all non-farm users)

(3) Farm.

For each of these categories populations were given for 1976. Water use coefficients for each category were also given. Although these coefficients reflect values within the Saskatchewan–Nelson Basin, the assumption is made that they are applicable to the rest of the population within the three provinces. The population within the Saskatchewan–Nelson Basin contains over 90% of the total population of the Prairie Provinces.

A percentage of ground-water use in relation to total water use was given for the first two categories, but no percentage was given for the farm category. D. Tate, Environment Canada (personal communication) estimates that 90% of the farm population relies on ground water.

Table B-1 identifies the 1976 population, total water use and ground-water use within the Prairie Provinces, and Table B-2 identifies the 1981 population, total water use and ground-water use derived in this report for the three Prairie Provinces. Although exact comparisons between the two tables cannot be made, it is evident that the 1981 estimates based on MUNDAT data for total water use and ground-water use are reasonable. The higher percentage of water use obtained from ground water in the 1981 estimates should not be considered a trend to more ground-water use in these provinces. This increase could be attributed to population inaccuracies of the 1981 MUNDAT data and generalizations on per capita water use coefficients for both sources.

Table B-1. Population and Total Water Use in the Three Prairie Provinces, 1976*

Population category (subsector)	1976 Population*	Per capita use† m^3/yr	Total water use ('000 m^3)	Percent of total water use obtained from ground water†	Ground-water use ('000 m^3)
Manitoba					
Urban	729 750	171	124 790	3	3 744
Rural					
(excluding farm)	189 852	41.9	7 958	85	6 764
Farm	101 904	69.3	7 067	90	6 360
Total	1 021 506		139 815	12‡	16 868
Saskatchewan					
Urban	516 602	173.8	89 785	18	16 161
Rural					
(excluding farm)	211 655	81.7	17 292	85	14 698
Farm	193 066	69.3	13 379	90	12 041
Total	921 323		120 456	36‡	42 900
Alberta					
Urban	1 385 330	224.9	311 560	2	6 231
Rural					
(excluding farm)	261 923	83.7	21 923	85	18 635
Farm	190 784	69.3	13 221	90	11 899
Total	1 838 037		346 704	11‡	36 765

*Values derived from 1976 data in the PPWB (1982a) study.
†Source: PPWB (1982a).
‡Value derived from provincial totals: $\frac{\text{Ground-water use}}{\text{Total water use}}$

Table B-2. Estimated Population and Total Water Use within the Prairie Provinces, 1981

Population subsector	1981 population	Total water use ('000 m^3)	Percentage of total water use obtained from ground water	Ground-water use ('000 m^3)
Manitoba				
Municipal	807 282	126 703	4	5 115
Rural	218 959	15 327	90	13 794
Total	1 026 241	142 030	13	18 909
Saskatchewan				
Municipal	615 000	107 412	26	27 899
Rural	353 313	24 732	90	22 259
Total	968 313	132 144	38	50 158
Alberta				
Municipal	1 684 600	364 808	5	17 214
Rural	533 124	38 719	90	34 847
Total	2 237 724	403 527	13	52 061

Source: 1981 MUNDAT (Environment Canada, 1981a).

Appendix C
Agricultural Section

APPENDIX C

AGRICULTURAL SECTION

Table C-1. Major Livestock Categories and their Daily and Annual Water Use Coefficients

Livestock type	Water use coefficients for livestock	
	L/day/head	m³/year/head
Milk cows (2 yr old and over)*	154	56.21
Steers (1 yr and over)	51	18.62
Bulls (1 yr and over)	97	35.41
Calves (under 1 yr both male and female)	25.5	9.31
Other cattle (over 1 yr and not included above)†	64	23.36
Pigs	6	2.19
Sheep	3.5	1.28
Horses	68	24.82
Chickens	0.28	0.10
Other poultry (turkeys, geese, ducks)	0.5	0.18

*Statistics Canada (1982a) did not have a "Milk Cow" (2 yr old and over) category but rather a "Dairy Cow" category. According to R. Burroughs, Project Manager, Agricultural Division, Statistics Canada, both categories are the same.

†Statistics Canada (1982a) identified two categories, "Beef" and "Heifers" in their publication. These numbers of livestock in each category were summed together and placed into the "Other Cattle" category.

Source: PPWB (1982c) Study "Agricultural Water Use," Appendix 3.

Table C-2a. Newfoundland — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	2 660	150
Steers	224	4
Bulls	242	9
Calves	1 629	15
Other cattle	2 208	52
Pigs	19 076	42
Sheep	7 435	9
Horses	340	8
Chickens	932 482	95
Other poultry (turkeys, geese, ducks)	3 438	1
Total		385

*Statistics Canada (1982a).

†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2b. Prince Edward Island — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	24 106	1355
Steers	19 550	363
Bulls	1 374	49
Calves	26 396	245
Other cattle	31 028	724
Pigs	116 843	255
Sheep	7 619	9
Horses	2 317	57
Chickens	222 729	23
Other poultry (turkeys, geese, ducks)	10 680	2
Total		3082

*Statistics Canada (1982a).

†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2c. Nova Scotia — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	36 237	2036
Steers	12 481	232
Bulls	2 180	77
Calves	34 818	324
Other cattle	54 483	1273
Pigs	139 344	305
Sheep	42 986	54
Horses	3 297	82
Chickens	3 435 103	350
Other poultry (turkeys, geese, ducks)	103 765	19
Total		4752

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2d. New Brunswick — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	28 050	1576
Steers	8 485	157
Bulls	2 677	94
Calves	30 796	286
Other cattle	40 934	956
Pigs	89 620	196
Sheep	13 317	17
Horses	2 972	73
Chickens	2 241 161	228
Other poultry (turkeys, geese, ducks)	88 256	16
Total		3599

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2e. Quebec — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	705 935	39 681
Steers	69 979	1 302
Bulls	40 632	1 438
Calves	366 034	3 406
Other cattle	483 111	11 285
Pigs	3 440 724	7 535
Sheep	112 121	143
Horses	24 682	612
Chickens	22 239 226	2 268
Other poultry (turkeys, geese, ducks)	1 999 094	363
Total		68 033

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2f. Ontario — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	552 748	31 070
Steers	622 781	11 593
Bulls	34 435	1 219
Calves	633 597	5 896
Other cattle	1 054 933	24 643
Pigs	3 165 837	6 933
Sheep	251 537	321
Horses	74 986	1 861
Chickens	33 915 205	3 459
Other poultry (turkeys, geese, ducks)	4 323 891	786
Total		87 781

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2g. Manitoba — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	83 188	4 676
Steers	137 301	2 555
Bulls	22 683	803
Calves	381 141	3 547
Other cattle	551 653	12 887
Pigs	874 995	1 916
Sheep	36 363	46
Horses	31 284	776
Chickens	6 155 042	628
Other poultry (turkeys, geese, ducks)	1 075 278	195
Total		31 050

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2h. Saskatchewan — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	84 619	4 756
Steers	187 011	3 481
Bulls	55 430	1 963
Calves	874 548	8 139
Other cattle	1 216 849	28 426
Pigs	574 334	1 258
Sheep	77 052	98
Horses	60 180	1 498
Chickens	4 410 585	450
Other poultry (turkeys, geese, ducks)	435 965	79
Total		50 144

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2i. Alberta — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	165 528	9 304
Steers	631 092	11 748
Bulls	89 514	3 169
Calves	1 307 238	12 166
Other cattle	1 999 515	46 708
Pigs	1 199 397	2 626
Sheep	201 294	257
Horses	118 708	2 946
Chickens	9 190 525	937
Other poultry (turkeys, geese, ducks)	1 100 962	200
Total		90 061

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-2j. British Columbia — Livestock Subsector, Annual Total Water Use

Type of livestock	No. of animals*	Total water use† ('000 m³)
Milk cows	89 279	5 018
Steers	79 111	1 472
Bulls	18 377	650
Calves	242 105	2 253
Other cattle	360 969	8 432
Pigs	254 895	558
Sheep	66 988	85
Horses	39 356	976
Chickens	9 975 871	1 017
Other poultry (turkeys, geese, ducks)	773 588	140
Total		20 601

*Statistics Canada (1982a).
†Value calculated by multiplying the (number of animals) × (water use coefficient).

Table C-3. Annual Total Water Use by the Irrigation Subsector

Province	No. of hectares under irrigation (ha)	Annual water use coefficient (m³/ha)	Annual total water use ('000 m³)
Quebec	14 000*	1016¶	14 224
Ontario	40 255†	1491**	60 020
Manitoba	6 935‡	3010††	20 874
Saskatchewan	70 700§	3700††	261 590
Alberta	393 969‡	4740††	1 867 413
British Columbia	100 475‡		524 003
Region 1	35 131	7112‡‡	249 850
Region 2	9 529	7112§§	67 770
Region 3	42 098	4572‖‖	142 470
Region 4	13 694	1016§§	13 913

* 1981 estimate by the Quebec Ministry of Agriculture (personal communication).
† Statistics Canada (1971).
‡ Statistics Canada (1982b, Manitoba-d, Alberta-e, British Columbia).
§ 1983 estimate by Saskatchewan Water Corporation (personal communication).
¶ Estimate by R.S. Broughton, McGill University (personal communication).
**Estimate taken from *Consumption Water Use in the Canada Section of the Great Lakes Basin 1975–2035* (Department of the Environment, 1979).
††Estimate derived from 1976 data from the PPWB (1982a) study

$$\frac{\text{Total water use}}{\text{Hectares of irrigated land (district irrigation and/or private)}}$$

‡‡Estimate by Bill Ross, South Okanagan Land Irrigation District (personal communication).
§§Estimate by J. Dyck, B.C. Environment (personal communication).
‖‖Estimate by D.S. Stevenson, Agriculture Canada (personal communication).

Appendix D
Industrial Section

APPENDIX D

INDUSTRIAL SECTION

Table D-1. Industrial Plant Subsector Breakdown by Category and Subcategory

Category	Code*	Subcategories
Manufacturing	10	Food and beverage industries
	16	Rubber and plastic products industries
	18	Textile industries
	25	Wood industries
	27	Paper and allied industries
	29	Primary metal industries
	30	Metal fabricating industries
	32	Transportation equipment industry
	35	Non-metallic mineral products industries
	36	Petroleum and coal projects industries
	37	Chemical and chemical products industries
Mining	05	Metal mines
	06	Mineral fuels
	07	Non-metal mines (except coal)
Thermal†	05	Metal mines — generation
	06	Mineral fuels — generation
	07	Non-metal mines — generation
	10	Food and beverage industries — generation
	16	Rubber and plastic industries — generation
	18	Textile industries — generation
	25	Wood industries — generation
	27	Paper and allied industries — generation
	29	Primary metal industries — generation
	37	Chemical and chemical products industries — generation
	57	Electric power (excluding hydro) — generation

*Code numbers represent Statistics Canada's Standard Industrial Classification.
†Note that some thermal plants practise cogeneration with the industrial processes.

Source: 1981 Industrial Water Use Survey.

Table D-2. Annual Total Water Use by Industry (self-supplied only), 1981 (values '000 m^3)

Region, province or territory	Manufacturing			Mining			Thermal			Total		
	Fresh	Brackish	Fresh and brackish	Fresh	Brackish	Fresh and brackish	Fresh	Brackish	Fresh and brackish	Fresh	Brackish	Fresh and brackish
Newfoundland	53 424	22 797	76 221	58 254	0	58 254	310	76 440	76 750	111 988	99 237	211 225
Prince Edward Island	1 119	1 010	2 129	0	0	0	0	700	700	1 119	1 710	2 829
Nova Scotia	87 567	135 809	223 376	5 543	5825	11 418	28 080	887 270	915 350	121 240	1 028 904	1 150 144
New Brunswick	196 216	25 206	221 422	15 190	0	15 140	82 500	721 830	804 330	293 906	747 036	1 040 942
Quebec	2 111 403	2 024	2 113 427	75 792	250	76 042	307 640	0	307 640	2 494 885	2 274	2 497 159
Ontario	4 145 077	2 138	4 147 215	114 162	0	114 162	14 924 310	0	14 924 310	19 183 549	2 138	19 185 687
Manitoba	84 398	83	84 481	12 706	0	12 706	55 570	0	55 570	152 674	83	152 757
Saskatchewan	36 565	0	36 565	22 834	2654	25 488	766 010	0	766 010	825 409	2 654	828 063
Alberta	219 229	127	219 356	137 747	546	138 293	996 360	0	996 360	1 353 336	673	1 354 009
British Columbia	2 053 215	73 294	2 126 509	119 833	4	119 837	334 140	24 040	358 180	2 507 188	97 338	2 604 526
Northwest Territories	875	0	875	14 032	0	14 032	0	0	0	14 907	0	14 907
Yukon Territory	4	0	4	10 374	0	10 374	0	0	0	10 378	0	10 378
Canada total	8 984 092	262 488	9 251 580	586 517	9279	545 796	17 494 970	1 710 280	19 205 250	27 070 579	1 982 047	29 052 626

Source: 1981 Industrial Water Use Survey.

Table D-3. Ground-Water Use by Industry (self-supplied only), 1981 (values '000 m³)

Region, province or territory	Manufacturing			Mining			Thermal			Total		
	Fresh	Brackish	Fresh and brackish	Fresh	Brackish	Fresh and brackish	Fresh	Brackish	Fresh and brackish	Fresh	Brackish	Fresh and brackish
Newfoundland	58	0	58	1 014	0	1 014	0	0	0	1 072	0	1 072
Prince Edward Island	621	0	621	0	0	0	0	0	0	621	0	621
Nova Scotia	4 345	47	4 392	1 604	0	1 604	0	0	0	5 949	47	5 996
New Brunswick	2 640	72	2 712	16	0	16	10	0	10	2 666	72	2 738
Quebec	16 425	41	16 466	8 799	0	8 799	0	0	0	25 224	41	25 265
Ontario	21 503	650	22 153	10 901	0	10 901	0	0	0	32 404	750	33 054
Manitoba	10 485	42	10 527	0	0	0	130	0	130	10 615	42	10 657
Saskatchewan	1 584	0	1 584	4 136	0	4 136	0	0	0	5 720	0	5 720
Alberta	6 175	127	6 302	9 388	33	9 421	0	0	0	15 563	160	15 723
British Columbia	27 012	219	27 231	16 909	0	16 909	9310	0	9310	53 231	219	53 450
Northwest Territories	0	0	0	9 168	0	9 168	0	0	0	9 168	0	9 168
Yukon Territory	0	0	0	0	0	0	0	0	0	0	0	0
Canada total	90 848	1198	92 046	61 935	33	61 968	9450	0	9450	162 233	1231	163 464

Source: 1981 Industrial Water Use Survey.

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